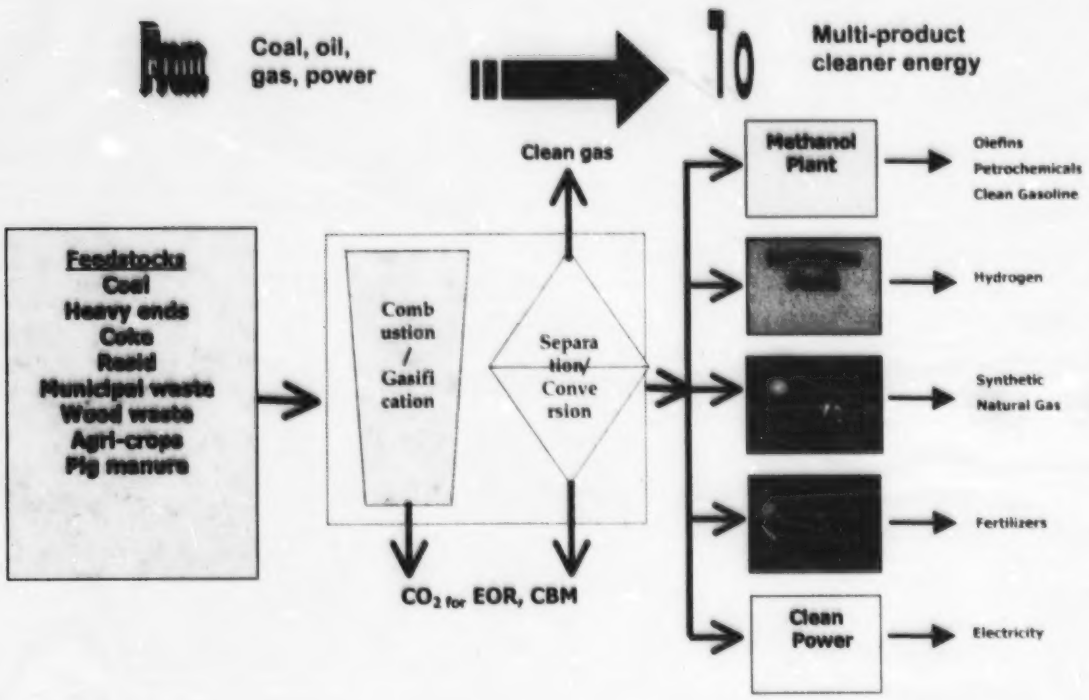
FINAL DRAFT
November 13, 2001

STRATEGIC BUSINESS PLAN 2002-2005
Alberta Energy Research Institute



AERI
Alberta Energy Research Institute

The URGENCY

Alberta has the world's greatest repository of hydrocarbon resources – 2.6 trillion tonnes of coal, 1.7 trillion barrels of oil and 200 trillion cubic feet of gas. Energy production is the foundation of Alberta's economy. Last year, 79% of Alberta's exports were energy based with oil and gas alone accounting for over $33 billion. The energy sector continues to be the major creator of wealth in the province and the catalyst for the knowledge based industry and diversified economy.

The current situation, however, is not sustainable.

Coal-fired plants generate over 70% of Alberta's electricity and there is a need for more coal to be used to meet the increasing demand for electrical capacity. Coal is seen as "dirty" by the public and its use is resisted using present technology. Development of cleaner coal burning technology will avoid the stranding of this plentiful and inexpensive resource.

Production from Alberta's conventional petroleum basins is declining. The decline in conventional oil production has averaged over 6% per year for the past 5 years. While over 70% of the conventional oil still remains in the ground, large portions are not recoverable with today's technology resulting in early well abandonment. For each 1% increase in the overall recovery factor, however, the estimated impact on government royalties alone is $5 billion.

The decline rate of new natural gas wells is alarmingly high – a 30% decline in the first year. The Energy and Utilities Board estimates a current replacement ratio for natural gas of only 50%. Alberta has three times the reserves of natural gas in coal beds than remaining in conventional sources. However, development of coal bed methane is at an early stage and is an unknown factor at this time.

The past decade has witnessed a major shift in investments for the development of conventional resources from the Western Canadian basin to foreign, offshore, and northern resources.

Production from bitumen and heavy oil has more than made up for the decline in conventional oil. This has come, however, at the expense of increased production costs and increased green house gas (GHG) and other emissions. Refineries in North America have not been designed to process bitumen or synthetic crude; therefore, increasing supply faces severe market limitations.

The Kyoto Accord and reduction in GHG emissions will place severe restrictions on the growth of the energy industry in Alberta, which is under pressure to rapidly transition to sustainable and cleaner energy. There have been little or no investments in research and technology and capability that is needed to support the development of clean power, value-added products/processes, renewable energy and address environmental concerns.

Ignoring the challenges facing Alberta's energy industry is to accept decline. A focus on technology to enhance the value of Alberta's resources while improving long-term environmental performance will secure the future.

The INTENT

The restructuring of research funding under the Alberta Science and Research Authority (ASRA) and the creation of the Alberta Energy Research Institute (AERI) facilitates an integrated approach for research and technology. AERI is the successor to the Alberta Oil Sands Technology and Research Authority (AOSTRA). AOSTRA had a single focus - research into oil sands production. The AERI mandate is research into any form of energy of importance to Alberta. The intent is to centralize and focus all government-supported energy research and respond effectively to the opportunities and risks resulting from global energy availability and price discontinuities. Strategic investments in energy research programs and innovation systems will ensure the utilization of existing and new energy resources to their fullest potential and Alberta will become the premier sustainable energy region in North America.

The VISION

Alberta maximizes the value of its energy resources and the prosperity of its citizens through energy technology development and implementation. It is recognized around the globe for leading-edge innovation in environmentally sustainable energy development, transportation and value-added use.

The MISSION

AERI works with industry and other government ministries to promote the research and technology advances required to discover, recover, process and transport Alberta's energy resources with an emphasis on environmental performance.

The ROLE

AERI's mission will be achieved by promoting collaborative research conducted by the private sector, government labs and universities. AERI will work closely with the Alberta Research Council, provincial Departments of Energy, Environment, Economic Development, Sustainable Resource Development and with the Federal Government to strengthen our energy sector. AERI's role is to take a long-term view, ensuring that the knowledge required for maximizing the value of Canada's resources continues to grow, by catalyzing and stimulating the research and development (R&D) of new technology.

The STRATEGIC PLAN

Premier Klein has stated that his goal is to make Alberta the premier energy provider in North America

The primary responsibility for the development and implementation of new technology belongs to industry; the role of government is to act as a catalyst, an integrator and help develop a critical mass of expertise. By co-investing in basic and applied research, as part of a cohesive strategy, government ensures that Canada has a competitive and sustainable energy industry that can grow to create wealth for the benefit of all Albertans.

Current government action could parallel previous strategic investments in oil sands R&D that helped secure Alberta's present prosperity.

Alberta is fortunate to have several energy resources in close proximity: conventional oil, natural gas, heavy oil, oil sands, coal and coal bed methane. The range of our energy resources means that we can think in terms of a Carbon, Hydrogen and Nitrogen strategy, letting one form of energy optimize another form, while harmonizing by-product utilization.

The strategy is based on the following research and development goals:

GOAL 1: *Clean coal*

- Cleaner energy[1] research to make coal acceptable for generating electricity, and in the process use coal and "opportunity" feedstocks to generate other products such as hydrogen, petrochemicals and steam.

GOAL 2: *Upgrading technologies*

- Research to improve the upgrading process so that synthetic crude is acceptable to a higher percentage of the refinery diet while at the same time strengthening the petrochemical industry.

GOAL 3: *Carbon dioxide (CO_2), management with energy production*

- A CO_2 storage program focused on CO_2 for enhanced oil and gas recovery and coal bed methane.

GOAL 4: *Improved oil and gas production*

- Research aimed at improved recovery from conventional and non-conventional resources while reducing energy intensity.

GOAL 5: *Fuel cells and hydrogen*

- Developing a research infrastructure and critical mass in support of the emerging fuel cell industry and the hydrogen economy.

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[1] In practical terms, "clean energy for electricity generation" means technology that is able to achieve environmental emissions standards equivalent to that of natural gas with the added benefit of CO_2 capture and storage.

The PROCESS

In order to achieve these goals, it will be necessary for AERI to have a multi-faceted and integrated approach, based on the following objectives:

The overall goals are to:

- ***Increase wealth and jobs for all Albertans***
- ***Make energy available at a reasonable price***

Position Alberta to take advantage of new technologies

Direct university research into strategic areas

- ***Balanced Portfolio:***
  Develop a balanced portfolio of energy research projects, based on current, near-term and future Alberta resource development needs.

- ***Program Integrator:***
  Harmonize the AERI research program with other energy research providers in Canada and the United States.

- ***Research Intelligence:***
  Build upon existing research strengths and occupy niche opportunities.

- ***Support University Energy Research:***
  Attract world-class researchers and industry to Alberta through a strong university based program.

- ***Technology transfer:***
  Encourage multi-company alliances to undertake major projects of common interest and ensure effective transfer of advanced technology.

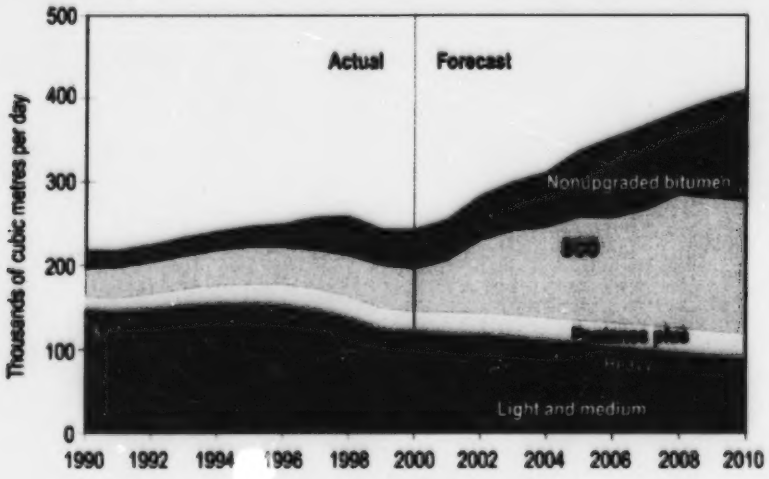
The PRIZE

The opportunities and outcomes for investments in specific energy forms include:

- **Oil Sands:** Alberta's oil sands reserves contain an estimated 1.63 trillion barrels of bitumen in place – about the size of the oil reserves in the Middle East. The Alberta government's $700 million investments, over the past 25 years, in research and development into bitumen production and upgrading from the oil sands deposits are about to pay handsome dividends. Industry is investing $30-50 billion in commercial projects over the next decade that will generate significant revenues and employment for the next 30-50 years. Continued research into less energy-intensive processes and better upgrading technology will ensure growth and commercial production from these resources is sustained for the long term.

- **Conventional Oil:** Alberta has 60.3 billion barrels of crude oil in place. Current production technologies leave around 70 percent of the original oil in the ground. Therefore, only 19.7 billion barrels are recoverable, most of which has already been produced. Our remaining established reserves are 1.9 billion barrels, with a reserve-to-

production ratio of seven years. As shown in the following figure[2], light and medium crude oil production will continue to decline. Improved production technologies, using solvents such as carbon dioxide, are urgently needed to extend these reserves. Government investments in enhanced recovery research will unlock more reserves, increase production rates and provide an environmental benefit by sequestering GHG such as carbon dioxide in depleted oil reservoirs.



- **Coal Bed Methane (CBM):** Alberta has vast reserves of methane in coal deposits, which have yet to be properly delineated; technologies to utilize reserves still need to be developed. Private sector interest is muted, due to a lack of knowledge, technologies and infrastructure. Government investment would signal interest in developing new production technologies for these resources and result in the environmental benefit obtained by replacing methane with carbon dioxide in underground coal seams.

- **Clean Coal:** Alberta's total coal resources are estimated at 2.6 trillion tonnes of which 620 billion tonnes are considered to be recoverable. About 26 million tonnes are used annually to generate over 70% of Alberta's electricity needs. The long-term sustainability of our electric power generation industry is dependent on its ability to convert to cleaner energy technologies. Through research investments, the government can take advantage of and adapt research and development results from elsewhere, to ensure the availability of cheaper electricity in Alberta, while creating an opportunity to export surplus electricity.

- **Petrochemicals:** In the next 25 years, the Alberta petrochemical industry will undergo a major transition as the supply of natural gas liquids (NGLs) feedstock gradually declines, but petrochemical demand continues to increase. By developing technologies that use the light ends from bitumen upgrading and other sources, Alberta could

[2] Alberta's Reserves 2000 and Supply/Demand Outlook 2001-2010, Alberta Energy & Utilities Board Backgrounder, September 2001

position itself to compete with the U.S. Gulf Coast as the premier producer of petrochemicals.

- **Renewable Energy:** New renewable energy technologies are being developed globally. Alberta has the natural resources and agricultural base to take full advantage of new technology developments in the area of biomass fuels, wind energy and solar energy. It has significant hydrogen supplies that will give Alberta the strategic advantage in the future "hydrogen economy". A watching brief will be maintained in these areas as a launching point for a more active development program, as required.

Goal #1: CLEANER ENERGY

Most of Alberta's electricity is generated from coal, resulting in the emission of pollutants and GHG. New technologies are being developed for clean power generation from coal and other feedstocks. The commercialization of such technologies will ensure that coal-fired power generation will continue to satisfy Alberta's electricity needs for decades.

Strategy:

- Develop a network linking provincial, national and global research activities in cleaner energy.
- Leverage funds from the federal government, industry and research funding sources into a cleaner energy research program that will be overseen by an independent steering committee, strongly linked to the AERI Board
- Promote bench scale and pilot projects in clean coal technologies, integration with other feedstocks and low intensity heavy oil upgrading, and in emissions sensing and mitigation.

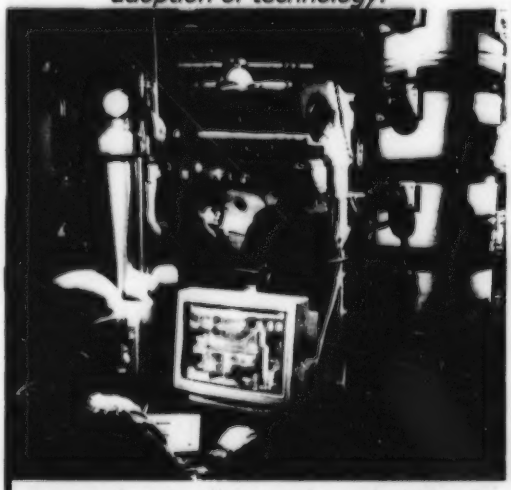
Performance measures:

- The number and value of cleaner energy projects funded.
- The number of demonstration/-commercial projects that integrate coal gasification with low-intensity upgrading and CO_2 management.

Priority: Cleaner energy research focussed on power generation from coal and other feedstock integrated with available energy sources and products.

Objectives:

1. *Promote research that will make Alberta's coal reserves acceptable for electricity generation and other products including hydrogen, petrochemical feedstocks and steam.*
2. *Coordinate the clean energy research activities of industry, ARC, Natural Resources Canada and the Universities of Alberta and Calgary to create a critical mass and encourage the early adoption of technology.*



Research into clean coal combustion at CANMET Energy Technology

Goal #2: UPGRADING TECHNOLOGIES

Many North American oil refineries cannot readily accept the synthetic crude that is currently produced from bitumen. Research is urgently needed to increase the value and percentage of synthetic crude that will be accepted by such refineries. This is especially important since bitumen and synthetic oil production is expected to double in the next five years. Research into lower aromatic and sulphur content will also make the products more marketable. It is also necessary to reduce the amount of energy that it takes to upgrade bitumen.

Alberta's ethane-based petrochemical industry is vulnerable to both supply and price of natural gas. Diversification of the feedstock will prevent decline and enhance growth of the petrochemical industry.

Strategy:

- AERI will conduct a technical audit of research programs to understand the benefits and help re-position upgrading research areas that involve less energy intensity and customized synthetic products.
- Work with industry, academia and research providers to evaluate innovations, research and market needs of the petrochemical industry. Solicit and fund value-added proposals.

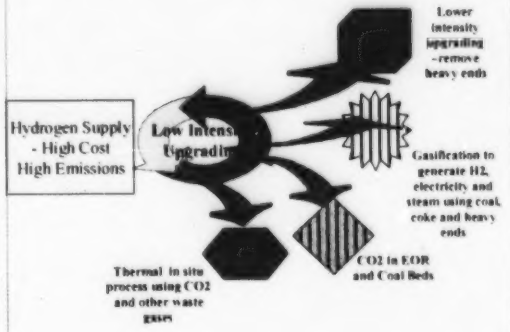
Performance Measures:

- Measurable decline in the amount of energy used in upgrading.
- Level of increased petrochemical R&D and increased supply and diversity of petrochemical feedstocks.

Priority: Higher valued products from upgrading of bitumen and feedstock for petrochemicals.

Objectives:

1. *Research aimed at increasing the value of synthetic crude and increasing its market share in North American refineries' feedstocks.*
2. *Research into reducing the energy intensity of bitumen upgrading.*
3. *Establish programs on producing petrochemical feedstocks from low-cost energy resources, such as coal, coke and bitumen; integrate bitumen upgrading and gasification with petrochemical processes to optimize product yields and quality.*


Lower intensity upgrading - remove heavy ends
Hydrogen Supply - High Cost High Emissions
Low Intens Upgradi
Gasification to generate H2, electricity and steam using coal, coke and heavy ends
CO2 in EOR and Coal Beds
Thermal in situ process using CO2 and other waste gases

Example of value addition by linking upgrading to gasification and recovery

Goal #3: CO_2 MANAGEMENT WITH ENERGY PRODUCTION

The need to manage risks associated with CO_2 emissions from energy production provides an opportunity for developing the policy, fiscal regimes and infrastructure to improve environmental performance while extending the life of Alberta's conventional resources. Developing the technology to rationally use conventional oil and gas and coal beds as a tool for CO_2 storage may prove to be of an even greater importance with Canada's ratification of the Kyoto Accord.

Strategies:

- Support research and technology in reservoir management of CO_2 EOR and studies related to separation, concentration and transport of CO_2.
- Support joint Alberta and Canada geological surveys to compile existing Alberta coal databases and survey Alberta coal beds to provide additional information on coal geology and methane content.
- Encourage the commercial production of CBM through workshops and technology transfer initiatives.

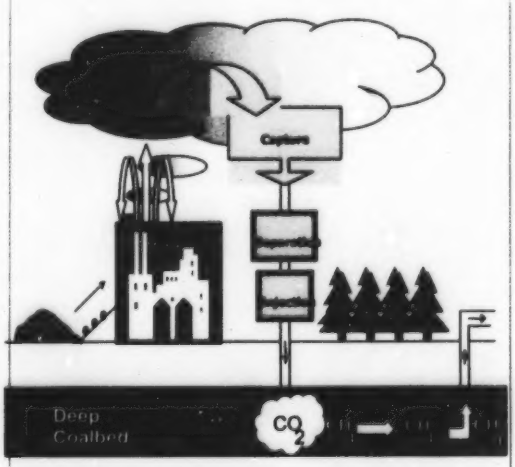
Performance Measures:

- Reduction in emissions of CO_2 and other pollutants in Alberta.
- Number of new technologies for CO_2 separation.
- Level of production of conventional and CBM resources using enhanced CO_2 technologies and variations.

Priority: Develop an energy management program for CO_2 to be used for enhanced oil and gas recovery and enhanced CBM production

Objectives:

1. *Resource quantification and mapping including evaluation of potential reservoirs for CO_2 EOR and CBM.*
2. *Selection and research and technology support for demonstration of CO_2 EOR projects.*
3. *Support enhanced CBM field pilots to develop technologies for CBM production and CO_2 sequestration.*



Example of "green" power plants and integration with enhanced CBM production.

Goal #4: IMPROVED OIL AND GAS PRODUCTION

The Alberta Energy and Utilities Board estimates decline in Alberta's conventional oil reserves from nearly 6.3 billion barrels in 1976 to 1.8 billion barrels today. The estimate for conventional gas is a decline from a peak of 63.5 trillion cubic feet to the current 42.4 trillion cubic feet.

Even with application of infill drilling and horizontal wells, some 60% of the oil will be stranded given current technology. Production from heavy oil and bitumen has more than made-up for the decline in conventional oil. This has come, however, at the expense of increased energy usage and emissions.

Strategies:

- With respect to bitumen and heavy oil resources, the focus will involve working with CONRAD on less energy intensive in situ and extraction processes, water usage and tailings management issues.
- R&D effort for conventional oil and gas will involve working with PTAC and CAPP to promote industry consortia and working groups (similar to CONRAD) with a focus on oil ad gas enhanced technology and optimizing economics.

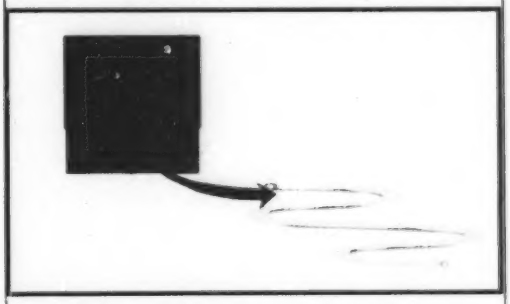
Performance Measures:

- The number and value of R&D projects and field tests in conventional oil and gas reservoirs.
- Number of tests of new technologies, which can reduce energy and water usage.
- Increased leverage of research funding from industry.

Priority: Invest in leading-edge research for improved recovery and less energy-intensive production of conventional and non-conventional oil and gas.

Objectives:

1. *Continue research to reduce energy intensity of bitumen and heavy oil recovery, in situ recovery and oil sands surface mined extraction.*
2. *Establish an effective enhanced oil and gas research and development program aligned with the strategies for CO_2 Management, recovery of gas from coal beds and mitigation of the stranding of conventional resources.*



Example showing a schematic of hydrotransport and low energy extraction (25 – 50^0 C)

Goal #5: FUEL CELLS AND HYDROGEN

The Alberta energy industry is a world leader. In order to maintain this lead, it must monitor and participate in all new high potential energy technology developments.

Fuel cells are a market area that is growing strongly. Two fuel cell manufacturers are currently located in this province. AERI is developing a technology roadmap to identify the technology needs of this industry and to help our industry grow.

Most of the hydrogen production in Canada is from natural gas. It is used mainly in oil upgrading and refining, in Western Canada. By the year 2050, hydrogen will be fuel of choice. In order to remain a premier energy provider, Alberta must participate in the research into the large-scale production, transportation and handling of hydrogen. Alberta must also monitor the progress made in biomass, solar and wind technologies.

AERI's strategy is to maintain a watch on renewable energy technologies, assisting in research areas such as fuel cells and hydrogen. It will establish a renewable energy database to avoid duplication of research that has already been done elsewhere and, when necessary, import such technologies into Alberta.

Performance measures will include an increase of renewable energy projects in the AERI portfolio and an increased growth of the fuel cell industry in Alberta.

Priority: Develop an energy research infrastructure in support of emerging fuel cell industry and hydrogen economy.

Objectives:

1. *Develop a Fuel Cells Research Strategy for Alberta as a component of the Integrated Energy Research Strategy.*
2. *Increase the portfolio of renewable energy projects, including areas such as fuel cells and hydrogen technology.*
3. *Interact with renewable and alternative energy industries and associations to establish their research priorities and assist research providers to address such priorities.*

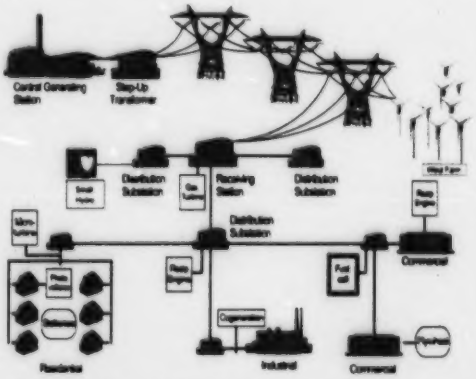


Illustration of the emerging energy supply through deregulation providing opportunity for distributed generation, fuel cell and "green" power.

APPENDICES

- **The Role of Government**
- **Benefits of an Integrated Energy Research Strategy**
- **Linkages to Government Goals**
- **List of Acronyms**

THE ROLE OF GOVERNMENT

Private energy companies are free to invest anywhere in the world based on maximum returns to their shareholders. Albertans are the shareholders of the province's natural resources; the government is the steward. Government must invest in research and technology in order to maximize the sustainable production and value of these resources. By co-investing in research, government ensures that Alberta is an attractive place for private companies to locate and prosper, thereby sustaining an economically viable environment that benefits the quality of life of all Albertans.

The provincial government has several critical stewardship roles, including leadership in energy R&D, looking after the public good (through energy conservation and environmental sustainability) and having a long-term vision for our prosperity. Three of these roles are:

- **Leadership in energy technology commercialization:** Through AERI, the government will have a first-hand look at technical, economic and other obstacles that may impede the development and implementation of new technologies. By addressing these obstacles, it will accelerate technology development and position our energy industry to take advantage of opportunities that arise during periods of price volatility. Advancements will happen faster through the investment and leveraging of funds, collaboration and by getting knowledge to those who can apply it.

- **Encourage R&D through funding leverage and risk sharing:** Government investments leverage R&D funds through collaboration, avoid duplication in research and reduce risk. Also, AERI will identify and invest in research to fill knowledge gaps, to ensure the by-products from one energy technology are optimally utilized by another technology, thereby maximizing the value of our energy resources.

- **Provide focus to ensure critical mass in key areas:** AERI contributes to the creation of a critical mass of researchers, developers and innovators required to ensure the long-term sustainability of our energy sector.

BENEFITS OF AN INTEGRATED ENERGY RESEARCH STRATEGY

By 2010, integrated energy companies should be able to provide clean and competitive energy service to the consumer. They will have the ability to draw upon several feedstocks and produce multiple products. For example, an oil sands extraction and upgrading plant will be able to use petroleum coke, heavy ends, coal or biomass for its heat source and produce synthetic oil, gas, electricity, hydrogen and petrochemicals. The CO_2 produced will be in concentrated form, ready for use in enhanced oil recovery and CBM projects. When the price of a particular energy feedstock becomes too high, the integrated plant will switch to a lower-cost feedstock.

Since Alberta owns multiple energy resources, an integrated multi-faceted energy research strategy is optimal. Research that shows how a lower-value energy form can either replace or be easily transformed into a higher-value energy form will allow private industry to adjust quickly to energy price spikes and optimize Alberta's energy resources. The shift in priorities and increased investments over a five-year period will result in a balanced portfolio of projects as illustrated in the Portfolio Management section.

LINKAGES TO GOVERNMENT GOALS

The Alberta Energy Research Strategy has linkages to other government departments and their respective goals. AERI has integrated these goals into the overall energy research strategy.

- **Economic Development ("Get Ready Alberta"), Goal 1:** Alberta is a world leader in innovation, research, development and commercialization of new ideas.
- **Economic Development ("Get Ready Alberta"), Goal 3:** Alberta is internationally recognized as a good place to invest and do business. Alberta businesses compete and succeed in a global marketplace.
- **Innovation and Science (INNSCI)/Alberta Science and Research Authority (ASRA), Goal 1:** Maximize the international competitiveness of Alberta's science and research system.
- **INNSCI/ASRA, Goal 2:** Promote effective technology commercialization, adoption and investment in Alberta.
- **INNSCI/ASRA, Goal 3:** Promote effective application of science and research for improving the stewardship of Alberta's resources and environment.
- **Alberta Energy, Goal 4:** Provide strategic research direction to achieve long-term energy and mineral development goals.
- **Alberta Energy, Goal 5:** Prepare a long-term energy outlook for Alberta that secures supply and benefits while positioning Alberta within a broader North American energy marketplace.
- **Alberta Energy, Goal 7**: Establish a customer choice framework for providing stable, affordable energy for Albertans.
- **Alberta Environment, Priority:** Made- In-Alberta Climate Change Strategy.

LIST OF ACRONYMS

AACI	AERI/ARC Core Industry
AERI	Alberta Energy Research Institute
AOSTRA	Alberta Oil Sands Technology and Research Authority
ARC	Alberta Research Council
ASRA	Alberta Science and Research Authority
CANMET	Canada Centre for Mineral and Energy Technology
CBM	Coal Bed Methane
CCPC	Canadian Clean Power Coalition
CO_2	Carbon Dioxide
CONRAD	Canadian Oil Sands Network for Research and Development
COURSE	Coordination of University Research for Synergy and Effectiveness
DOVAP	Dover Vapex Pilot
EGR	Enhanced Gas Recovery
EOR	Enhanced Oil Recovery
GHG	Greenhouse gas
HC3	High conversion hydro-cracking process with integrated hydro-treating
INNSCI	Innovation and Science
NCUT	National Centre for Upgrading Research
NGL	Natural Gas Liquid
NRCan	Natural Resources Canada
OSLO	Other Six Lease Owners
PTAC	Petroleum Technology Alliance of Canada
R&D	Research and Development
SAGD	Steam Assisted Gravity Drainage